NAVAL RESEARCH LABORATORY

NAVAL CENTER FOR SPACE TECHNOLOGY

Ground Segment Description Document
for the
Full-sky Astrometric Mapping Explorer (FAME)

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 SCOPE

1.1 Identification

This document applies to the Full-Sky Astrometric Mapping Explorer (FAME) Observatory.

1.2 Purpose

This document provides an overview of the FAME ground segment.

1.3 System Overview

The FAME observatory will provide the positions, proper motions, parallaxes, and photometry of nearly all stars as faint as 15th visual magnitude with accuracies of 50 microarcseconds (uas) at 9th visual magnitude and 500 mas at 15th visual magnitude. Stars will be observed with the Sloan Digital Sky Survey g', r', i', and z' filters for photometric magnitudes. This is accomplished by a scanning survey instrument with a mission life of 2.5 years and an extended mission to 5 years.

1.4 Document Overview

This document is organized as follows:

- Section 1.0, *Scope:* Purpose and contents of this document, and an overview of the FAME program.
- Section 2.0, *Blossom Point Satellite Tracking Facility:* Provides an overview of facility, which will be used as the FAME Mission Operations Center.
- Section 3.0, *Science Operations Center:* An overview of USNO's Science Operations Center.

2 BLOSSOM POINT SATELLITE TRACKING FACILITY

2.1 Introduction

The Naval Research Laboratory (NRL) maintains the Blossom Point (BP) Satellite Tracking Facility, which provides engineering and operational support to a number of complex space systems for the Navy and other users. Located at Blossom Point, Maryland on the north shore of the Potomac River between the Port Tobacco River and Nanjemoy Creek, BP benefits from natural isolation and level terrain, free of tall obstacles. A 2000-foot buffer zone surrounds the cleared twenty-three acre square containing the station. This ideal topographic setting assures freedom from interference to track satellites at great distances and low angles to the horizon. A surveyed helicopter landing pad is available to support quick-reaction and VIP visits. The FAME mission will use a dedicated, limited-motion antenna system to provide 24/7/365 on-orbit support.

BP provides command, control, and communications, network engineering and management, and operations and management support to the FAME program, as shown in Figure 2-1. BP provides flight operations and level zero mission data processing. BP consists of the ground antenna system, mission operations center, and the existing infrastructure and is fully capable of provide FAME command, control, and management.

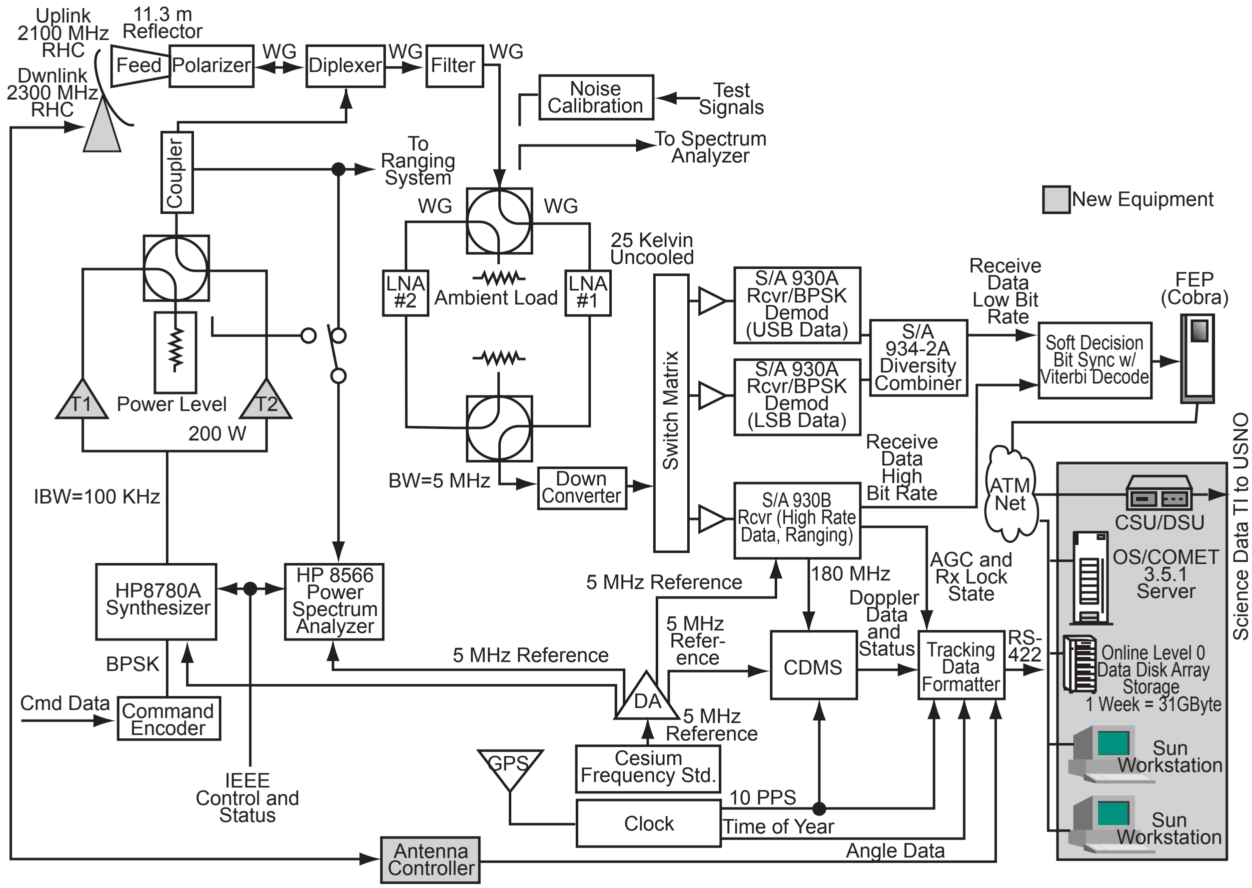

Figure 2-1. Ground System Block Diagram

2.2 Command, Control, and Communications

BP provides communications services during all mission phase, including development, launch, early on-orbit operations, and mission data collection. Extensive redundancy and backup capabilities provide enhanced reliability.

2.3 Operations and Management

An experienced industry and government team will provide the expertise to oversee the FAME program on a long-term basis. BP's shared infrastructure and high level of autonomy substantially reduces mission operations and management costs for long-term operations.

2.4 FAME Operational Mission Support

BP provides 24/7/365 FAME mission support to ensure optimal operational effectiveness and to maximize the productive life on on-orbit assets. BP's long-term development strategy emphasizes state-of-the-art technology, open standards, and software reuse to reduce operational costs while improving performance and increasing ground station autonomy. BP maintains a better than 99.9% system availability.

BP will support all phases of the FAME mission, including:

- Pre-launch integration and compatibility testing.
- Post-launch orbit injection support and engineering evaluation.
- Mission commanding.
- Engineering data acquisition and analysis.
- Anomaly detection and resolution.

- Station keeping.
- Simulation of vehicle tasking to de-conflict state of health maintenance and payload tasking.

2.5 Ground Station Software

2.5.1 Layered Architecture

The BP Ground Station software architecture consists of the five layers shown in Figure 2-2. The base layer is a Portable Operating System Interface (POSIX) compatible COTS Operating System such as UNIX, with network components supporting TCP/IP. The next layer is the COTS product OS/COMET that provides the infrastructure and services to support a distributed, scalable command and control environment. OS/COMET also provides Telemetry, Commanding, and Recording services that are driven by run-time table structures compiled from a database specified by statements included within the COMET Control Language (CCL). The third layer consists of components that provide centralized control and scheduling of Ground Station resources as well as generic data reduction, processing, and analysis functions. The fourth layer consists of Operational Support Software, including planning and modeling software, and the fifth layer encapsulates all mission unique functions. UNIX workstations distributed over local or wide area networks provide the platform for the user to interact with BP and missions. The Human Computer Interface (HCI) is characterized by MOTIF and X-Windows based displays. The OS/COMET Graphical User Interface (GUI) and client software for the Ground Station control, data processing, and operational support components comprise the majority of these displays.

Software reuse is essentially 100% for the COTS products contained in layers 1 and 2. Using OS/COMET's Comet Control Language (CCL), the mission vehicle's command, telemetry, and decommutation must be specified. Likewise, text and graphical windows must be defined to support the mission's concept of operation. The Ground Station control and data processing layer is highly reusable and essentially requires tailoring to the mission's concept of operations, failover strategy, resource allocation strategy, and Ground Station devices and configuration. FAME mission orbit, maneuver planning, vehicle modeling and simulation characterize this layer. The intention of the fifth layer is to encapsulate truly unique functions of the mission and vehicle, and therefore is not reusable.

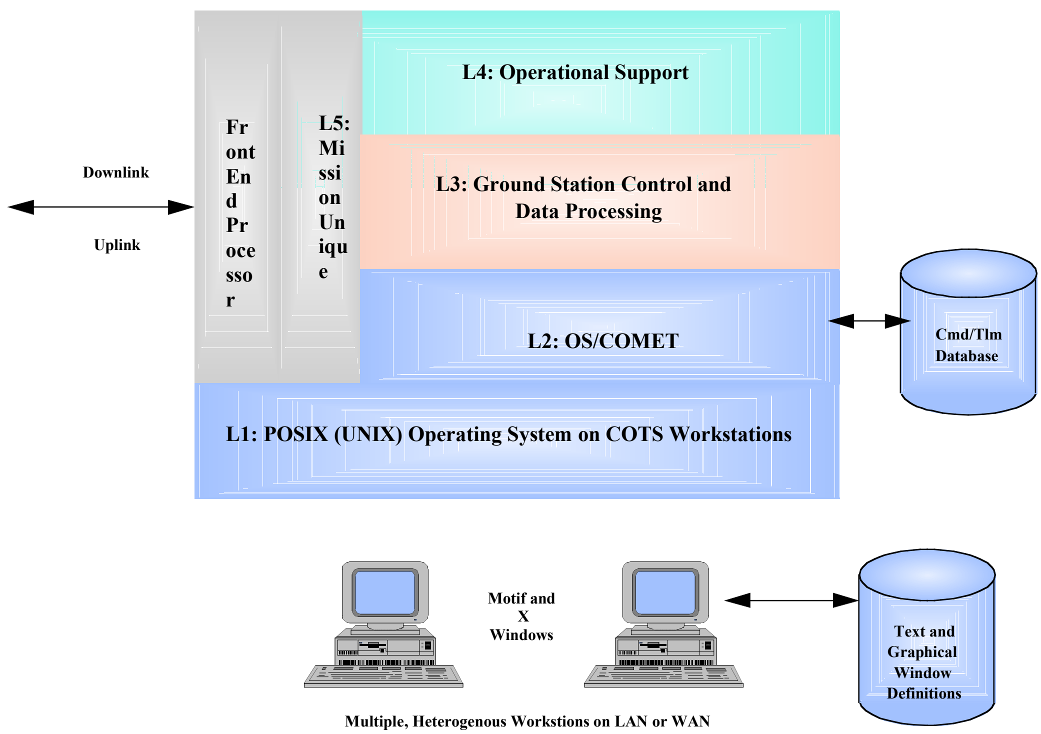

Figure 2-2. Blossom Point Layered Software Architecture

2.5.1.1 OS/COMET

OS/COMET is an integrated tool set and run-time environment for developing and deploying command and control software. Since 1982 the COMET product has been improved and re-engineered to the point where it can support a Telemetry, Tracking, and Command (TT&C) application at less than 20% of the total lines of code of a custom solution. OS/COMET, the newest edition of the COMET product, offers the application developer a distributed processing, client-server model for developing command and control environments for satellite integration and test, launch support, and mission operations. OS/COMET facilitates rapid development of Command and Control applications at a low cost.

The OS/COMET infrastructure consists of the four OS/COMET Computer Software Configuration Items (CSCIs) described in Table 2-2. These CSCIs interact with existing network and interprocess communication protocols to support a distributed system architecture. Collectively these CSCIs comprise the OS/COMET Software Bus.

Table 2-1. OS/COMET Infrastructure

CSCI	Description
System Administration (SAC)	Implements a distributed name service. Monitors process state. Controls process activity.
Communication Services (CSC)	Implements local queuing, routing, and node-to-node transfers.
Data Distribution (DAD)	Replicates shared data areas throughout the distributed system.
Symbol Processing (SYM)	Provides shared data handling via offline facilities and online functions.

Features provided by the Software Bus include:

- Distributed name service.
- Process control.
- Point-to-point, broadcast, and multicast communication.
- Database shadowing on all nodes requiring shared data.

The OS/COMET Software Bus provides the infrastructure, messaging, and data distribution for OS/COMET's Service Layer. The services include Telemetry Processing (TLM), Command Processing (CMD) and Recording and Logging (RLC). TLM provides telemetry services for planning, execution, and evaluation functionality. TLM uses a database, table-driven approach to dynamically perform telemetry processing for a particular vehicle. During execution, TLM decommutates the telemetry stream, applies alarm limits, and sends data to the software bus for distribution in real-time. For evaluation, TLM processes telemetry measurands, conducts derived item processing, and makes the data available for archiving. CMD provides the vehicle commanding functionality required for planning and execution. Planning utilizes CMD services, which allow the user to define and store command data. CMD provides execution functionality for validation or rejection of commands with associated real-time displays. Additionally, higher level applications cooperate with CMD to extend command selection and manipulation. During execution, RLC records all uplink commands. RLC may also record any system data specified, as well as support the telemetry playback capability. OS/COMET provides application programmer interfaces in both C and ADA, allowing the application access to all OS/COMET services including a high-level control language called CCL that may be executed from any COMET console or compiled into executable scripts, and a comprehensive GUI.

Use of an OS/COMET-based solution is flexible and scalable because:

1. All of the processes communicate over a logical software bus, and the application data (telemetry, for example) is distributed over that software bus. One software process can receive data from another process, or send a message to another process, independently of physical node.

2. Multiple instances of the same process can be instantiated to provide parallel processing and redundancy. Constellation programs such as Iridium and GPS are easily accommodated using multiple instances of common processes. Dual nodes configured for hot backup provide a no-data-loss approach to critical, real-time applications.
3. The OS/COMET CCL is extensible. Mission unique functions can be coded and plugged into the software bus. New CCL directives can be added to the database syntax file to provide perform file level control for launching and controlling the new function.

The operational product is composed of the standard components shown in Table 2-3 that are layered on the OS/COMET applications and software bus to distribute data, messages, and processes.

Table 2-2. OS/COMET Components and Function

OS/COMET Component	Function
Software Bus (Table 2-2)	A node-independent mechanism to distribute data, messages, and processes over arbitrary network architecture composed of UNIX workstations.
API	Bindings in C, ADA, and C++ that allow other COTS or custom components to interface to the Software Bus for message and data distribution.
TLM	Database driven telemetry decommutation, derived item generation, and sample data processing, including aperture compression, limit checking, alarm notification, and engineering unit conversion.
CMD	Database driven commanding and command verification.
GUI	X/Motif based graphical user interface to provide control, trending, and graphical and alphanumeric displays.
LPC	High level language processing engine for interactive or automated procedures (PERFORM Files) comprised of CCL directives.
RLC	Real-time recording and logging application to capture telemetry data, CCL directive execution, alarms and other significant system events and data.
TAS	Builds long-term telemetry archive files from RLC files for processing by DRA (a legacy component).
EEH	System wide error and event handling.
UMI	Universal Memory Image processing.
CSS	Computer system services.

2.5.1.2 Ground Station Control and Data Processing

Evolution of the BP architecture has abstracted generic capabilities for Ground Station control and data processing from mission and site specific approaches. These components shown in Table 2-4 provide a reusable layer for implementing Ground Station control and data processing functions for a specific satellite program.

Table 2-3. Components for Ground Station Control and Data Processing

CSCI	Description
Operations and Control (OAC)	System scheduling and automated control planning and execution capability.
Resource Management (REM)	Resource management planning.
Ground Station Equipment Control (GSEC)	Device control.
Data Reduction and Analysis (DRA)	Archived data evaluation.
Data Handling Facility (DHF)	Archiving capabilities for evaluation.

2.5.1.2.1 Ground Station Control

OAC, REM, and GSEC are client-server applications that cooperate to provide Ground Station control. OAC controls the Ground Station configuration to support execution of the mission plan by employing REM to determine resource availability. GSEC controls, queries, and provides status for the ground equipment that composes a subset of the resources over which REM controls the allocation strategy.

2.5.1.2.1.1 Operations and Control (OAC)

OAC provides automated scheduling and control to BP planning and execution capabilities. OAC schedules network node activities across multiple ground sites, if desired. Automated activities include scheduling satellite or constellation contacts and launching Operating System script files and OS/COMET perform files to perform pre-stored functions associated with a scheduled activity. OAC also manages automated failure detection and failover, application initiation in support of scheduled activities on networked nodes, and multi-node schedule management capabilities. Furthermore, the OAC client provides detailed visibility and control of schedule processing and node management. The server, OAC Executive, handles schedule and event processing. The client, OAC Graphical User Interface (OACGUI), manages displays and provides operator interaction. This interface provides displays for:

- Event Schedule
- Orbital Status
- Azimuth-Elevation-Range (AER)
- World View

The OAC executive parameters may be modified via the OAC control window. These parameters are categorized into classes for executive mode, event class, executive access, constellation, and satellite. Executive parameters include: node names, nodes to start up COMET, epoch of the event schedule, maximum pass length, how far into the future to allocate resources, heart beat rate of the executive, orbit data production rate, and AER production rate. The Event Class maintains pass event information. The Executive Access parameters allow the user to set read, write, delete, and modify privileges for any OACGUI client. The constellation class includes parameters for:

- List of existing constellations
- List of member satellites
- Constellations active in the event schedule
- Constellation names
- Prepass command
- Lead time to run prepass command
- Postpass command
- Lag time to run postpass command
- Pass type
- Resource management configuration file
- Min and max azimuth
- Min and max elevation
- Min and max range
- Min and max constraints on equator crossing

2.5.1.2.1.2 Resource Management (REM)

REM utilizes the client-server model to provide a generic solution to resource management at BP. Resource definitions and priority rankings define the resources, allocation strategy, and conflict resolution strategy. REM employs rules and COTS based expert systems to resolve resource conflict. REM schedules and tests devices, and provides a manual override for operator recovery from device malfunctions. The Resource Blackboard displays the current resource schedule. The REM master console provides the ability to define or modify resource definitions or the Resource Blackboard.

The REM client provides a means of modifying or defining resources. A single resource consists of nine resource attributes: name, operational state, priority, status, number of clients allowed, configuration information, comment information, resource unique information, and a resource lock. The user may create, modify, or delete the resource information, which is stored in a database. Requests for multiple resources may be organized into resource groups.

Virtual resource allocation by the REM server prepares the Ground Station for satellite contacts. Resource allocation is "virtual" because REM does not actually own the resources it manages. REM supports two categories of resource requests: type and *hard*. A *type* request is a request for management of a certain type of resource. An example of a *type* request is a request for an antenna to support a satellite contact. This request does not ask for a particular antenna. A *hard* request, on the other hand, is a request for a particular device. The REM server supports multiple *hard* and *type* requests combined into a single request. All resource requests are stored in a database, and the REM server monitors and reports the status of requests. Request conflicts are resolved by priority, with the request with longer time-in-system selected in cases of equal priority. Similarly, resources are allocated by priority. Resource scheduling is accomplished via the COTS G2 inference engine. The REM server tracks resource usage and archives resource utilization statistics. Resource status is maintained in memory files (Mfiles) that are accessible by OS/COMET. By updating the status in the Mfiles, the REM server notifies REM clients of the resource status changes via a multicast message over the OS/COMET software bus.

A REM client may either attach to a particular REM server or initiate a REM server on a particular node. As part of attaching to the REM server, the REM client automatically makes requests for resource, request, and control parameter information. The REM server maintains communications statistics, which may be displayed by any client. Since multiple clients may attach to a particular server, the REM server controls access to information via semaphores. The REM server is responsible for producing OS/COMET CCL configuration files for use by OAC in configuring the station during prepass and postpass. The server also maintains an event log, which contains system events sorted by current time and event type. The REM client displays graphical information for:

- Resource information
- Virtual requests and associated resources
- Resource groups
- Server control parameters
- Available network nodes
- Resource utilization statistics
- System events
- Generated CCL configuration files
- Station signal flow

The Station Signal Flow display offers particular utility to the operation staff by graphically depicting resource connectivity, resource status, and signal status with the capability of point-and-click link creation and modification of station signal flow.

2.5.1.2.1.3 Ground Station Equipment Control (GSEC)

GSEC offers a client-server solution to ground station equipment control. The GSEC server provides equipment control and device status to OS/COMET processes. The GSEC client provides graphical windows for accessing ground station device status and device control parameters. For a new Ground Station, GSEC must be tailored to include site-specific device driver libraries, site-specific telemetry stream configuration, and connectivity to external applications. The GSEC design offers configurability, portability, and ease of integrating new equipment.

A site-specific database contains all of the ground station hardware configuration information. The GSEC server polls each hardware component upon startup and upon receipt of a refresh request. GSEC specific CCL directives are used to query the server for device information and to specify device characteristics. The GSEC server also provides device status by injecting a ground station telemetry stream into the OS/COMET TLM service.

The GSEC client allows the user to initiate or terminate GSEC server processing on any of the network nodes. The client allows the user to specify status polling intervals and time out values, and displays status and statistics for each hardware component including:

- Current status for each configured device
- Current status of a particular device's GSEC server
- Commands sent to a device
- Completion status of each directive
- Current access mode for each device

In summary, GSEC provides the Ground Station infrastructure for device control and utilizes OS/COMET CCL directives for device specification and query. Injection of ground station hardware status as a telemetry stream permits GSEC client accessibility from any node and allows external applications continuous access to device status.

2.5.1.2.2 Data Processing

Software components described in this subsection provide utilities that handle the archival and retrieval of satellite data.

2.5.1.2.2.1 Data Reduction and Analysis (DRA)

DRA adds graphical and programmatic interfaces and archived data processing functionality to the evaluation capability of BP mission. A graphical user interface offers time, type, revolution, and satellite selections for processing archived data. Statistical analysis of the data includes options such as fitting curves and finding minimum data, maximum data, rate of change, mean, median, mode, and sigma. Filters, expressions, and user defined processing components allow further data analysis capability. DRA plots data graphically, generates reports, and stores results for future analysis.

2.5.1.2.2.2 Data Handling Facility (DHF)

DHF brings archiving functionality to the evaluation capability of BP mission. Using a relational database approach, DHF ingests and archives all downlinked (derived) telemetry, memory readouts, and uplinked commands. DHF tracks the storage and long-term archival of such data, as well as that of engineering specific databases for trend analysis.

2.5.1.3 Operational Support Software (OSS)

OSS provides capability for orbit analysis, mission planning, and flight operations. Components in this layer are discussed under subsequent headings in this section.

2.5.1.3.1 Orbit and Covariance Estimation and Analysis program (OCEAN)

Definitive orbits for FAME are produced using the Orbit and Covariance Estimation and Analysis program (OCEAN). OCEAN is a state-of-the-art, orbit determination, ephemeris propagation, and timing calibration software tool. In this application, the orbits are computed using range and range-rate tracking data. To satisfy the velocity accuracy requirement for FAME, OCEAN uses high fidelity force modeling including estimated perturbations for solar radiation pressure. OCEAN conforms to the IAU2000 standards, based on the International Celestial Reference System. The fundamental inertial frame is the Geocentric Celestial Reference Frame and the Earth centered Earth fixed frame is the International Terrestrial Reference Frame.

Extensive covariance and Monte-Carlo analyses carried out prior to launch to show the ability to meet the velocity knowledge requirement with the OCEAN software and the available tracking data. Once on orbit, solutions will be generated using the weighted least squares batch method or the Kalman filter smoother. Perturbation model and filter tuning will be performed during early orbit operations to ensure the highest quality ephemeris. During routine orbit operations, estimates of the error covariance will be provided along with the estimated ephemerides.

2.5.1.3.2 Event Sequence (EVTSEQ)

The Event Sequence program is a scheduling tool that displays the orbit, attitude, and planning activities for the FAME mission. Information such as view periods and eclipses are displayed in a graphical format. Using a simple input file, subsystem engineers provide information to the program that later becomes a schedule of attitude and orbit maneuvers, as well as commanding and engineering activities for the mission.

2.5.1.3.3 Constellation

Constellation, a program that runs on a Silicon Graphics workstation, is used to simulate and analyze FAME visibility and connectivity to BP. It has two dimensional and three-dimensional display capabilities.

2.5.1.4 Mission Unique Software

This section provides brief descriptions of software components unique to BP.

2.5.1.4.1 Wideband Analysis and Signal Processor (WASP)

A wideband data processor, the WASP CSCI simultaneously processes downlink data in several formats from up to eight sources and provides output data to the unclassified area called the Satellite Health and Maintenance (SHM) via parallel and Ethernet interfaces. After stripping housekeeping telemetry from wideband frames, the WASP formats the data into complete telemetry frames. Selectively filtering and processing wideband packets, the WASP performs real-time statistical analyses of wideband data such as averaging, standard deviation, peak deviants, event counting, and error counting. Additionally, the WASP furnishes the ability to reconstruct memory dumps and various satellite subsystem reports. The WASP CSCI contributes execution and real-time evaluation capability to the BP software architecture.

2.5.1.4.2 EEM Display and Graphics Environment (EDGE)

The EDGE, another mission-specific CSCI, provides evaluation capability to BP mission. Primarily a user interface to MDP and the WASP, the EDGE displays subsystems, raw data values, engineering values, packets, products, and events. Any fetched data is stored locally by the EDGE. Additional functionality offered by the EDGE consists of configuration interfaces to the WASP and MDP, and user selection of data sources.

2.5.1.4.3 Satellite Specific Ground Software (SSGS)

The execution capability of BP must satisfy requirements that change and evolve with the mission. SSGS contains software that meets those evolving execution requirements. This CSCI is a composite of special cases. For example, SSGS contains several functions that aid failure analysis on past and current satellites. SSGS provides the extension of functionality to the BP software architecture.

2.5.1.4.4 Uplink/Downlink Interconnect Matrix (UIM/DIM)

As site-specific CSCIs, UIM and DIM provide execution capability to configure and deconflict the uplink and downlink paths, respectively, during pre-pass for later use during contact. Configuration of the uplink path involves radio frequency (RF) signal path selection and verification, modulation path selection, and RF output verification. Configuration of the downlink path involves downlink command processing and configuration switching. Additionally, UIM and DIM both prove useful when conducting diagnostic system tests. The UIM and DIM CSCIs perform generically with respect to satellite missions at BP.

2.6 LEO Ground Station Hardware

BP architecture makes extensive use of COTS hardware. This section describes the hardware in terms of data flow.

The telemetry data path is composed of an antenna, feed components, low noise amplifier, receiver(s), bit synchronizer, frame synchronizer, and a telemetry processing computer. Data paths are configured using software controlled switch matrices. The hardware components are controlled using both serial and Ethernet connections. The telemetry is processed on a VAX 6000 computer. Change only telemetry is distributed over the 10 Mb Ethernet to graphical display workstations. The workstations each have two 20 inch color monitors. Telemetry data, command logs, and processing outputs are archived to clustered disk arrays for long term on-line storage. The computing resources are located in an unclassified area (SHM). The commanding path is comprised of a processing computer, Command Encoder Unit (CEU), exciter, transmitter, and an antenna. These components are again connected via a software controlled switch matrix.

Table 2-7 and Table 2-8 contain a list of the front-end hardware as well as the major computing resources available at the BP ground site. These lists do not include PCs, MACs, X-Terminals, terminal servers, modems, routers, fiber optics, printers, and disk arrays.

Table 2-4. Current FAME Front End Telemetry and Command Paths

Hardware	Manufacture	Quantity
FAME Limited Motion Antenna – 11.3m	TBD	1
Ranging/Range Rate Processor	TBD	1
S band antenna -33’ (Backup to 11.3m)	DATRON	2
C band antenna -20’	DATRON	5
Antenna Control Unit	DATRON	7
Receiver (series 930)	Scientific-Atlanta	12
Combiner (series 934-2)	Scientific-Atlanta	3
Bit Synchronizer (model 7715)	Decom Systems Inc.	8
Frame Synchronizer (Time Tagger)	Innovative Concepts Inc.	4
Ensemble	Timing Solutions	1
Cesium Clock/distribution	Hewlett-Packard	4
Command Encoder Unit (610)	Silver Engineering	2
Exciter	Hewlett-Packard	4
Downlink Data switch matrix (DLM, SDFM, EDFM)	AlliedSignal, Inc.	3
Uplink switch matrix	AlliedSignal, Inc.	1

Table 2-5. Computing Resources

Hardware	Manufacture	Quantity
Sparc 20 Workstation	Sun	3
Sparc 5 Workstation	Sun	1
Sparc 10 Workstation	Sun	2
Sparc 2 Workstation	Sun	2
Alpha 400-4/233 Workstation	DEC	2
VAX 4000-60 Workstation	DEC	19
VAX 4000-600A	DEC	2
VAX 6000-620	DEC	6

2.7 Software Engineering

The BP software engineering process includes proven industry-accepted practices for analysis, design, implementation, and qualification. Structured analysis and design techniques make up the principle methodology for requirements analysis and software design. Graphical based Computer Aided Software Engineering (CASE) tools are used to produce data and control flow models that capture the design. Data Item Descriptors from MIL-STD-498 standardize the documentation products.

The software engineering process partitions the analysis and design into four stages. The first stage consists of system requirements analysis, and includes the identification of FAME mission constraints and the risk impact of integrating new technology. The utilization of hardware and software COTS products is evaluated for potential use in the solution. The output from this stage is a System Segment Specification (SSS). The second stage is the architecture design and software requirements allocation stage. The system requirements are decomposed into software requirements that are allocated to existing CSCIs, development CSCIs, or COTS products. This stage concludes with the generation or update of specific CSCI Software Requirements Specifications (SRS).Preliminary CSCI design occurs in the third stage. Each CSCI is carefully evaluated by peer review to ensure that all requirements are covered. Prototyping for risk assessment and the use of CASE tools for capturing the design are important practices during this stage. Feasibility studies may be conducted to evaluate the application of new technologies to the CSCI requirements. The third stage concludes with the generation of the Software Design Document (SDD) and Interface Design Document (IDD) for all CSCIs. The final design stage involves critical evaluation of the CSCI design. In this stage, the engineer creates prototypes to benchmark against performance criteria. Lead engineers for each CSCI present the design for peer review. After the critical design review, the SDD and IDD are finalized and implementation begins.

Software development for product implementation follows the spiral model that combines the best features of classic approaches (e.g., the waterfall), utilizes rapid prototyping, and analyzes risk at each iteration of the spiral. The product is generated through a series of builds, each giving increased functionality. Each build is qualified via a regression test before integration into BP baseline. The regression suite consists of CSCI level test cases that verify system control and performance criteria. Test cases are reviewed to ensure requirements traceability to the SRS. Once the build has successfully performed against the regression test suite, the configuration-managed baseline is deployed for LEO operations. The previous baseline is always maintained online for an immediate fallback capability.

BP software engineering methodology consists of defined processes utilizing proven practices for the development and deployment of command and control software. For well over a decade, BP has enjoyed a successful history of the cost-effective production of robust ground station baselines, covering four generations of technology and architecture upgrades, without disruption to mission operations.

In general, the execution section covers the functionality required to control the ground station, receive and process telemetry, command the satellite, validate spacecraft configuration, and archive data. Typically, some software modifications and database generation would be required to provide complete functionality for new FAME requirements.

2.7.1 Operational Configuration

During prepass, BP allocates the data path hardware using the REM software. Data paths are then configured by the interaction of OAC, GSEC, and OS/COMET software. This involves setting up two data paths for each satellite: telemetry and commanding. The telemetry path includes the antenna, receiver, [combiner], bit synchronizer, decryptor, frame synchronizer, time tagger, and the telemetry processing software (TLM). Software configures each piece of hardware in the data path. The path connections are provided by software controlled data matrices. The commanding path includes the commanding software (CMD), the encryptor, Command Encoder Unit (CEU), the exciter, the transmitter, and the antenna. Again, a software controlled switch matrix provides for various hardware connections. The data paths are setup in less than 30 seconds. The hardware in the data path is polled to detect failures. Workstations are automatically configured and connected to the proper command and telemetry paths. Various displays are initiated which depict vehicle health and configuration. The data paths are validated during prepass. If a piece of equipment fails, REM may automatically choose new hardware and reconfigure the path. The user may choose to change the path with a simple graphical or alphanumeric command interface.

During the contact phase, BP software uses the OS/COMET Command and Telemetry (C&T) software. The command software provides a flexible, database driven, command, and command verification system. The Telemetry system (TLM) provides database driven telemetry decommutation, derived item processing, aperture compression, engineering conversion, limit checking, and alarm notification. The Command software (CMD) provides for command formatting and transmission. Various processing parameters for the TLM and CMD software may be modified using the online commands. All telemetry collected, commands issued, operator inputs and pass plan inputs are recorded during the contact phase using the Recording system (RLC). Pass plans are executed using Command Language scripts called “perform files”. The perform files may execute in both interactive and batch modes. Software automatically detects and isolates anomalous conditions in satellite configurations. Graphical and alphanumeric displays are available for all aspects of satellite and ground station measurands.

During the postpass phase, the data paths are automatically disconnected and made available for subsequent use. The recorded data is processed for long term archival. This involves the saving of command logs, the compression and storage of satellite memories, the compression and storage of all telemetry, the creation of summary logs, saving logs and automatically notifying the appropriate user of any errors.

One of the major functions of BP's ground system software is to maintain the on-board FAME memory. The TLM software processes on-board memory dumps to produce memory image files. These image files are compared against the command image. Areas that do not properly compare are reloaded. A configuration management system is used to maintain each satellite memory.

2.7.2 Special Software/Hardware Requirements

The special software requirements involve tools for configuration management activities. The special hardware requirement provides monitor slave consoles to the system.

2.7.2.1 Current Capability

BP Configuration Management Plan has been in effect since 1989. It covers all software, databases, operational procedures, and documentation. System Problem Reports, Software Problem Reports, Database Change Requests, Software Change Requests, and other forms are used extensively throughout all cycles of development and operations. Automated procedures exist to perform configuration management and form generation.

OS/COMET provides monitor slave console capability on any available terminal or workstation device that is connected to the LAN or WAN. These consoles provide the capability to monitor telemetry, but do not allow commanding.

3 SCIENCE OPERATIONS CENTER

3.1 Introduction

3.2 Payload Planning

3.2.1 Payload Activity Plan

3.2.2 Command Load Generation & Validation

3.3 Payload Data Analysis

3.3.1 Raw Sensor Data

3.3.2 Onboard-Calibration Data

3.3.3 Payload Housekeeping Data

3.3.3.1 Payload Trending

3.3.4 In-Situ Calibration Data *(Does this apply to FAME?)*

3.3.5 Algorithm Definition, Development, and Validation

3.3.5.1 Flight Software Validation and Maintenance (including star catalog)

3.4 Archiving

3.4.1 Processing

3.4.2 Distribution